

Contributions to the Knowledge of the Alpheid Shrimp of the Pacific Ocean

Part II. Collection from Arno Atoll, Marshall Islands¹

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THIS PAPER reports upon a collection of snapping shrimp made by Dr. Robert W. Hiatt and Dr. Donald W. Strasburg, of the University of Hawaii, at Arno Atoll in the southern portion of the Radak chain of the Marshall Islands. Under the sponsorship of the Pacific Science Board with funds from the Office of Naval Research, they visited Arno during the summer of 1950 as a part of a scientific team to investigate the total ecology of the atoll. One additional shrimp reported upon was collected by Dr. J. W. Wells of the same investigation.

This study of the snapping shrimp from Arno was initiated under a grant administered by the U. S. National Museum and the Pacific Science Board under a contract between the Office of Naval Research, Biology Branch, and the National Academy of Sciences, (NR 160-175); some help in the final phases of the study was made available through a grant to the author from the National Science Foundation (NSF-G-1754).

To avoid repetitious synonymies and bibliographies in this series of papers, whenever a full citation for a species has been given in an earlier paper, by myself, reference is made to this citation. In this present paper reference is made only to Part I of these studies, describing collections from the Mariana Archipelago

(Banner, 1956). Type specimens for the new species described in this paper will be deposited in the United States National Museum.

ARNO ATOLL

The nature and biology of Arno Atoll has been covered in a series of preliminary reports by members of the investigation team, published (in mimeographed form) in the *Atoll Research Bulletin* (issued by the Pacific Science Board), Numbers 3-11, 1951-1952. A comprehensive book on these studies is now in preparation and specialized scientific reports are appearing in technical journals.

Arno is an irregularly shaped atoll centered about 7° 05' N., 17° 40' E. and about 27 miles across its longest axis (Fig. 1). It consists of 133 islands and islets, only a few of which are large enough to support human habitation. The outer margin of the atoll drops off steeply into waters of profound depth; within, the lagoon is estimated to be 100-200 feet deep. The ocean communicates with the lagoon through a series of passes, deep or shallow. The atoll lies in the belt of northeasterly trades and at the southern edge of the North Equatorial Current, which may be replaced during some of the months of northern summer by the Equatorial Countercurrent. The ring of islands is surrounded on both inner and outer margins by coral reefs of varying vitality and breadth, depending upon conditions of wind, surf, sediment, etc.

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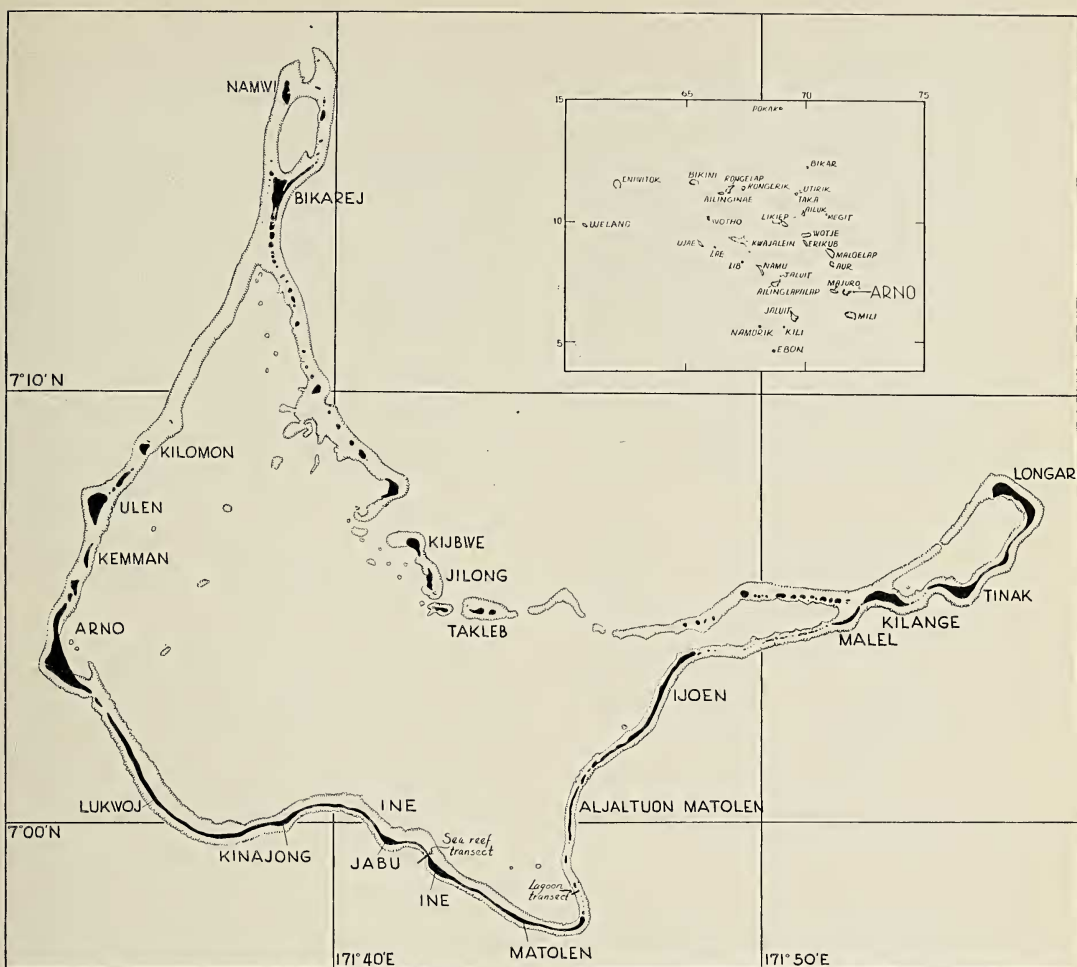


FIG. 1. Map of Arno Atoll, showing collecting stations. *Insert:* A map of the Marshall Islands, showing the location of Arno.

HABITATS OF THE SHRIMP

The studies made by Dr. Hiatt include two ecological sections of the reef in the extreme southern section of the atoll, one on the seaward and one on the lagoon side. The study of the seaward reef was made near the village of Ine, in a region quite protected from the prevailing winds and surf; that of the lagoon reef was made off the islet of Makin, some 4 miles away.

The method of taking the transects was the same in both cases. A strip 50 feet wide and divided into sections, 50 feet long on the seaward reef and 100 feet long on the lagoon

reef, was laid out normal to the shore and running from the beach to water beyond "skin diving" depth. The animals in each section were collected, given field identification and preserved; in the shallow zones this was done by wading, in the deeper by "skin diving."

The contours found on both transects were about the same, showing a broad, relatively flat, gradually sloping reef centering about the height of mean low water. An abrupt change in slope marked the outer margins of the reef flat, with the slope becoming steep on the lagoon reef and precipitous on the ocean side.

A complete report on the ecological study is in preparation by Dr. Hiatt. For this report on a small section of his collections, loaned to me for this study, Dr. Hiatt has permitted me to extract and summarize the following information from his field notes about the zones and specific habitats of the shrimp:

E-1-2. Section XI, seaward reef. Slope beyond edge of reef flat, about 450 feet from shore. Reef face at an angle of about 60°. 82 species of coral collected down to depth of 30 feet, no species being dominant. Alpheids commensal with *Antedon*, a sea lily found clinging to the underside of coral ledges.

E-1-106. Section III, seaward reef. 50-100 feet from beach. Level about that of mean low water (0.0); on low tides area with dry areas and shallow pools. Corals not flourishing, *Montipora gaimardi* the dominant species. Sand and coral fragments in depressions. Alpheids in interstices of *M. gaimardi*.

E-1-122. Section IV, seaward reef. 100-150 feet from beach. In general similar to Section III, about same level. Alpheids as in Section III.

E-1-149. Section V, seaward reef. 150-200 feet from beach. Inner portion alone exposed on extreme low water, outer portions covered by 2-5 inches of water. Level of extreme low water marks division between *M. gaimardi* and *Acropora pectinata* zones. Alpheids as in Section III.

E-1-285, 290. Section VI, seaward reef. 200-250 feet from beach. Water standing at all tides, reef flat bare with no loose sand. Zone with mixed *M. gaimardi* and *A. pectinata*. Alpheids in group 285 collected from living heads of coral and in holes in dead coral, and in group 290 from living heads of *Pocillopora*.

E-1-305. Collected from a brackish pond on Malel Island.

E-1-306. Section VII, seaward reef. 250-300 feet from shore. At tides below 0.3, tips of growing heads of coral exposed. *A. pectinata* dominant coral, covering much of area;

Pocillopora luxuriant. Alpheids from dead bases and living branches of coral; some from living heads of *Pocillopora*.

E-1-387, 388. Section VIII, seaward reef. 300-350 feet from shore. Highest parts of corals exposed only on extreme low waters. *A. pectinata* dominant with *Pocillopora* secondary; a brown alcyonarian, *Lobularia krempfi*, also occurring in numbers. Alpheids collected from heads of *Acropora* and *Pocillopora*.

E-1-611, 630, 643, 648. Section IX, seaward reef. 350-400 feet from shore. Section similar to Section VIII, the depth slightly greater and area commonly flooded with foam from surf much of day. *A. pectinata* and *Pocillopora* still dominant corals. Alpheids collected from heads of *Acropora* (617,643), *Pocillopora* (619, 630), and *Stylophora* (648).

E-1-670. Section II, seaward reef. From edge of water at mean high tide to a point 80 feet seaward. Exposed beachrock pitted and covered with fine, short algae; area marked by large tide pools varying from 4 to 8 inches deep. Alpheids collected from tide pool.

E-2-169, 311. Section II, lagoon reef. From mean high tide level to 100 feet towards the lagoon. Outer margin uncovers at 0.0 tide. Covered with quite smooth beachrock, with a few shallow tide pools; outer portions covered by a fine sand veneer. No corals present. Alpheids collected under loose slabs of beachrock (169) and in holes in the rock (311).

E-2-343, 382. Section IV, lagoon reef. From 200-300 feet from shore, depth from 4 to approximately 60 feet. Area with bottom covered with sand and coral rubble, and numerous species of coral with those of the genus *Acropora* dominant. Alpheids collected from heads of *Seriatopora hystrix* (343) and *Stylophora* (382).

E-2-360. Section III, lagoon reef. From 100-200 feet from shore. Depth from 0.0 to 4 feet. Section of bottom covered with fine sand and coral rubble; luxuriant growth of corals with species of *Acropora* dominant. Alpheids collected from *Stylophora mordax*.

ATHANAS Leach

Athanas djiboutensis Coutière, 1897

For synonymy, see Banner, 1956.

LOCALITIES: One specimen each at E-1-290 and E-1-388.

DISCUSSION: The two specimens cannot be assigned positively to this species for they are both fragmentary, lacking their chela and some other appendages. However, the appendages still remaining, and especially the form of the rostrum and the orbital spines about the eyes, compare almost perfectly with the specimens from Saipan identified as this species.

Athanas marshallensis Chace

Fig. 2

Athanas marshallensis Chace, U. S. Natl. Mus., Proc. 105(3349): 17, fig. 8, 1955.

LOCALITIES: One non-ovigerous female from E-1-122.

DISCUSSION: This specimen differs in only one way from the description and figure of Chace: in this specimen the extracorneal spines reach almost to the anterior margin of the eyes, instead of midway along the eyes as in Chace's specimens. It is likely, however, that the eyes are rotated backwards towards the body, for the "collar" of the anterior carapace that usually fits snugly about the eyes is loose and stands out from the corneas in this specimen.

METABETAEUS Borradaile

Metabetaeus minutus (Whitelegge)

Betaeus minutus Whitelegge, Austral. Mus., Mem. 3: 147, pl. 7, fig. 4, 1897.

Metabetaeus minutus Borradaile, Zool. Soc. London, Proc. 66: 1014, 1898.

Metabetaeus minutus Coutière, Soc. Ent. de France, Bul. 1899(19): 374, 1899a.

LOCALITIES: Four specimens, all females without eggs, maximum length 17 mm., E-1-305.

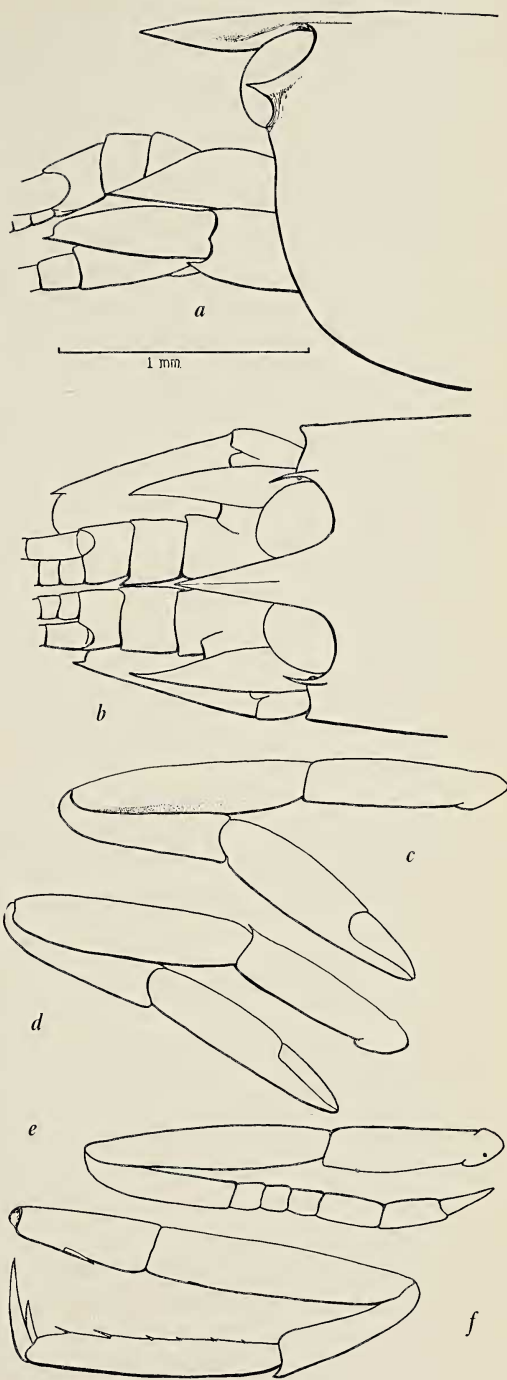


FIG. 2. *Athanas marshallensis* Chace. a, b, Anterior body region; c, right cheliped; d, left cheliped; e, second leg; f, third leg. (All same scale.)

DISCUSSION: These specimens agree almost perfectly with Whitelegge's original description and with the later redescrptions. The only differences found are in the anterior body region when compared to the plate of the original description. In these specimens the rostrum is almost an equilateral triangle with straight sides and slightly rounded tip, while Whitelegge showed and described his specimen as having a slightly more narrow rostrum with concave sides and an acute tip. Further, the concavity between the base of the rostrum and the orbital spines is more pronounced. Finally a difference is found on the relative lengths of the antennular and antennal peduncles, for in these specimens the antennular peduncle is slightly longer than the antennal, rather than the reverse as described by Whitelegge. These differences are minor and most likely of no importance.

Otherwise the specimens agree in the general form, the proportions of the appendages, the branchial formula and even in the possession of a brown spot on *corpus mandibulae* described by Coutière.

The type specimens came from a mangrove swamp, and, previous to this report, were the only specimens known. The ones described from Arno came from a brackish pond.

SYNALPHEUS Spence Bate

Comatularum Group

Synalpheus carinatus (de Man)

Alpheus carinatus de Man, Arch. f. Naturgesch., 53: 508, pl. 22, fig. 2, 1887.

Synalpheus carinatus de Man, Siboga Exped. 39a¹(2): 210, pl. 5, fig. 23, 1911.

nec Synalpheus carinatus Pearson, Report on Pearl Oyster Fisheries, p. 83, pl. 2, fig. 9, 1905.

LOCALITIES: One specimen at E-1-2, (commensal with *Antedon*, a sea lily).

DISCUSSION: This specimen agrees perfectly with the characteristics given by de Man. The ova are 1.1 by 0.7 mm. The species will be

discussed more fully in a later paper. Hiatt notes that the color in life was brownish-black, the same as the host, *Antedon*.

Synalpheus consobrinus de Man

Synalpheus consobrinus de Man, Nederland.

Dierk. Ver., Tijdschr. II, 11: 111, 1909.

Synalpheus consobrinus de Man, Siboga Exped., 39a¹(2): 204, pl. 6, fig. 21, 1911.

LOCALITIES: One specimen at E-1-643.

Neometis Group

Synalpheus charon charon (Heller)

Fig. 3

For synonymy, see Banner, 1956.

LOCALITIES: Two specimens each at E-1-617 and E-1-630.

DISCUSSION: These four specimens are of the parent subspecies with the expanded base to the superior unguis of the third to fifth legs, and with a rostrum of uniform taper.

One specimen from E-1-617, however, had a greatly expanded palm of the large chela with greatly reduced fingers. The condition is slightly more pronounced than that found in *S. macromanus* Edmondson (1925: 9), and at first the specimen was tentatively identified as that species. But *S. macromanus* has a conical inferior unguis on the third leg and is otherwise similar to *S. paraneomeris* Coutière, while this specimen is identical to *S. charon* except for the form of the large and small chelae.

The question is how this enlargement of the chela should be interpreted. When there was but the one specimen known as *S. macromanus* it was logical to consider the modification to be of specific worth; if this specimen were similar to *S. macromanus*, that species would have been considered as more valid. However, with specimens related to two different species showing a parallel mutation, I believe that the condition could best be interpreted as a growth anomaly that may occur in several species of this genus. The fact that this spec-

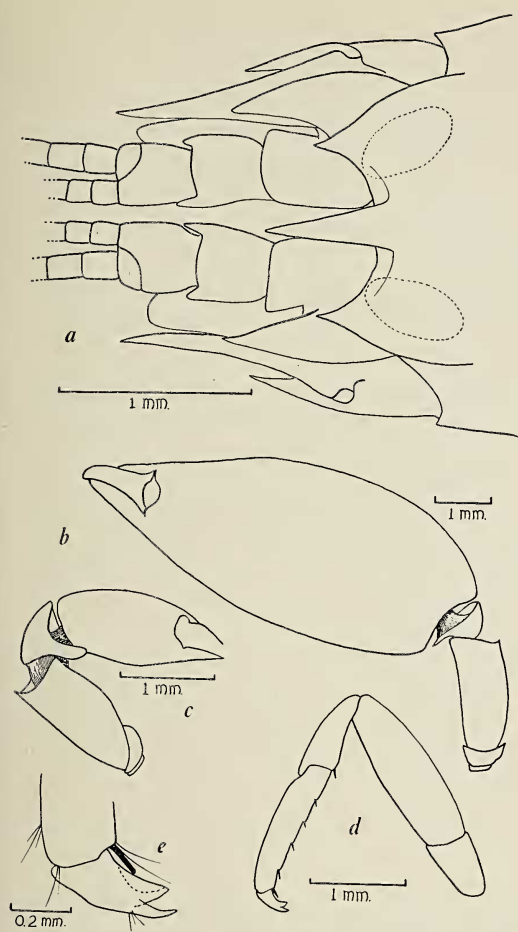


FIG. 3. *Synalpheus charon charon* Banner, aberrant form. *a*, Anterior body region; *b*, inflated large chela and cheliped; *c*, small cheliped of normal form; *d*, third leg; *e*, third leg, dactylus.

imen was one of a sole pair, male and female, the other being plainly *S. charon charon*, collected at one locality would offer support to this conclusion.

If this be so, then the original *S. macromanus* must be considered to be an aberrant form of *S. paraneomeris* Coutière.

Synalpheus paraneomeris Coutière

For synonymy, see Banner, 1956.

LOCALITIES: One specimen at E-1-106, 3 at E-1-306.

Coutierei Group

Synalpheus coutierei Banner

Fig. 4

Synalpheus coutierei Banner, Pacific Sci. 7(1): 36, 1953.

Synalpheus biunguiculatus Coutière, Soc. Ent. de France, Bul. 1898(11): 232, figs. 1-4, 1898 [and other authors—see Banner *op. cit.*].

nec Alpheus biunguiculatus Stimpson, Acad. Nat. Sci. Phila., Proc. 1860: 31.

LOCALITY: Three specimens at E-2-382.

DISCUSSION: These specimens are plainly of this species as illustrated by Coutière (*loc. cit.* and 1905: 873, pl. 31, fig. 8). However, they show slight differences in the proportions of the various parts of taxonomic significance, most apparently in the antennular peduncle, wherein the second article is relatively longer, in the small cheliped, in the dactylus of the third leg, and in the telson. These variations are shown in Figure 4.

Coutière (1898) has shown some variations in the anterior regions and in the dactyli of specimens collected in various parts of the Indian Ocean which approach the differences noted here; he also (1905: figs. 8, 10) described and depicted the form found in the Maldive and Laccadives, and described as a separate variety a form whose variations markedly exceed those of this group of specimens. I believe that considering the variations already reported and the variations in related species of *Synalpheus*, no taxonomic importance should be attached to the slight differences found in these specimens from Arno.

Synalpheus lophodactylus Coutière

Synalpheus lophodactylus Coutière, Soc. Philomath. Paris, Bul. IX, 11(5): 7, 1908.

Synalpheus lophodactylus Coutière, Linn. Soc. London, Trans., Zool. II 17(4): 421, pl. 61, fig. 11, 1921. [Text the same as 1908 reference, plates not previously published.]

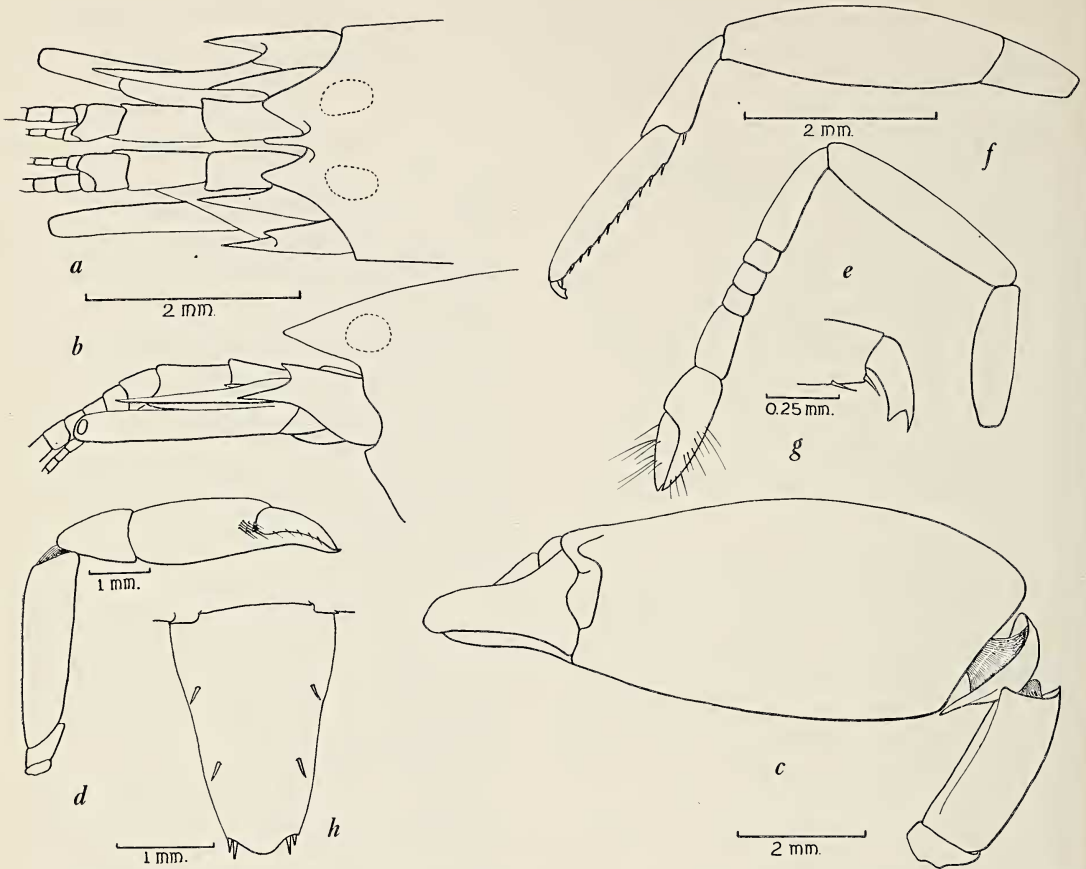


FIG. 4. *Synalpheus coutierei* Banner. *a, b*, Anterior body region; *c*, large cheliped; *d*, small cheliped; *e*, second leg; *f*, third leg; *g*, third leg, dactylus; *h*, telson.

LOCALITY: One female, collected at station E-2-343.

DISCUSSION: This specimen agrees well with Coutière's description and figures of his type, the sole specimen reported until now, except for several minor details. The setae on the small chela, shown as a definite tuft and described as "une brosse de soies sériées . . . moins sériées et moins abondantes que dans le groupe *laevimanus* . . .", appear to be less abundant in the distal tuft in this specimen and are also found proximal to the tuft in a row leading towards the articulation. The inferior distal margin of the merus of the third leg bear a feeble movable spine, instead of being unarmed as depicted by Coutière. Finally, the posterior lateral angles of the telson

are produced into slender acute teeth almost as long as the lateral distal spines instead of being broader and relatively shorter as shown by Coutière. However, the proportions of the small chela and third legs are almost exactly the same as in the type.

The specimen described by Coutière lacked the large chela, which is intact but slightly distorted in this specimen. It is of typical form for the genus, with the fingers occupying the distal 0.3 of the chela, and the height being about 0.4 of the total length (this proportion may not be accurate because of the condition of the appendage). The merus is 0.5 as long as the chela and 2.5 times as long as broad. The merus and the dactylar articulation are unarmed.

ALPHEUS Fabricius

Megacheles Group

Alpheus deuteropus Hilgendorf, 1878

For synonymy, see Banner, 1956.

LOCALITY: One specimen at E-1-387.

Alpheus collumianus probabalis

Banner, 1956

For synonymy of these subspecies and the parent species, see Banner, 1956.

LOCALITY: One specimen from the coral reef at Ine, collected by Wells.

DISCUSSION: The single specimen of this subspecies is markedly more hairy than were the specimens from Saipan; the long setae are especially noticeable on the antennular peduncle, the chelae, and the third and following legs. Moreover, the meri of the third and fourth legs bear 5-6 spines, instead of 4 as in the type, while the merus of the large chela has only 2 small weak spines instead of 6 strong spines that were carried by the type.

Alpheus collumianus medius Banner, 1956

LOCALITIES: Two specimens at E-1-387, 1 at E-1-617.

Macrochirus Group

Alpheus gracilis var. **simplex** Banner, 1953

For synonymy, see Banner, 1956.

LOCALITIES: Two specimens at E-1-306, both defective; 1 at E-1-387.

DISCUSSION: This single intact specimen is almost identical to the specimens from Hawaii except that it bears a trace of a rostral carina, a condition also noted in one of the aberrant specimens from Hawaii. The external spine of the uropod is black.

The two other specimens are assigned to this species with question for they are lacking their chelae and some of the other appendages.

The parts remaining, as well as the structure of the anterior carapace, agree very well with the specimens from Hawaii.

Alpheus ventrosus Milne-Edwards, 1837

For earlier synonymy, see Banner, 1956.

Alpheus sp. Coutière, in Fauna and Geog. Maldive and Laccadive Archipelagoes 2 (4): 882, pl. 74, fig. 19, 1905.*Crangon latipes* Banner, Pacific Sci. 7(1): 82, fig. 27, 1953.

LOCALITIES: Four specimens at E-1-290; 3 at E-1-306; 2 at E-1-387; 3 at E-1-617; 5 at E-1-630; 1 at E-2-343.

DISCUSSION: Specimens from station E-1-630 and E-1-290 present an incomplete intergradation from the form described as *C. latipes* and the mature *A. ventrosus*. The intergradation indicated by these specimens is confirmed by specimens from other areas and will be discussed more fully in a subsequent paper. One specimen in this collection shows the darkened spine on the uropods (as discussed in the specimens from Saipan).**Alpheus amirantei** Coutière*Alpheus amirantei* Coutière, Soc. Philomath. Paris, Bul. IX, 11(5): 15, 1908.*Alpheus amirantei* Coutière, Linn. Soc. London, Trans., Zool. II, 17(4): 421, pl. 63, fig. 16, 1921. [Text the same as 1908 reference.]

LOCALITY: One specimen at E-1-611.

DISCUSSION: This specimen appears to be somewhat intermediate in many characters between the type that Coutière described for the Indian Ocean and the Hawaiian form. The relative lengths of the antennular peduncle, antennal peduncle and scaphocerite are subequal, like Coutière's specimen, instead of having the scaphocerite markedly the longest. The basicerite bears a relatively strong spine, like the Hawaiian specimen. This specimen, a female, has slightly longer fingers to the large chela than does the Hawaiian form. The second carpal article of the second leg is 2.7

times the length of the first, instead of 2.3 in the Hawaiian form, and 3.0 in Coutière's. The inferior distal tooth of the merus of the third leg is longer and more acute than in the Hawaiian form, therefore more like the type specimen. Finally, the Arno specimen is unlike both previous forms in the armature of the merus of the large and small chela. In Coutière's specimen the inferior internal margin of the merus carried a series of rounded serrations terminating in a strong acute tooth; in the Hawaiian specimens the serrations were lacking, and the tooth was weaker; in the Arno specimen the tooth also is lacking. The merus of the small chela was armed with a tooth in the type but in both the Hawaiian and Arno specimens the tooth is lacking.

However, as the specimen agrees well with the general description of *A. amirantei*, these differences are considered to be at most sub-specific, and are more likely to be individual variation.

Alpheus nanus (Banner) 1953

For synonymy, see Banner, 1956.

LOCALITY: Two specimens at E-1-306.

DISCUSSION: Like the specimens from Saipan, the sole specimen with the chelae intact, a male, had spinules on the inferior internal margin of the merus; both large and small chelae had seven such spinules. The other specimen, a female, was lacking in both chelae.

Alpheus paragracilis Coutière, 1897

For synonymy, see Banner, 1956.

LOCALITIES: One specimen at E-1-106; 2 at E-1-285; 3 at E-1-387; 2 at E-1-617.

Alpheus macrochirus Richters

Alpheus macrochirus Richters, Meeresfauna der Insel Mauritius und der Seychellen, Decapoda, p. 164, pl. 17, figs. 31-33, 1880.

Alpheus macrochirus de Man, Arch. f. Naturgesch. 53(1): 519, 1887.

LOCALITIES: Two specimens at E-1-306; 2 at E-2-360.

DISCUSSION: These specimens agree well with the short original description, with the characteristics given in de Man's key and discussion (1911) and with the three figures in Coutière's *Les Alpheidae* (1899, figs. 51, 52, 261).

Crinitus Group

Obesomanus Subgroup

Alpheus lutini Coutière, 1905

For synonymy, see Banner, 1956.

LOCALITIES: Three specimens at E-1-106; 12 at E-1-122; 30 at E-1-149; 5 at E-1-285; 5 at E-1-290; 16 at E-1-306; 5 at E-1-387; 5 at E-1-611; 1 at E-2-343; 1 at E-2-382.

DISCUSSION: One specimen preserved in formaldehyde has a body colored pale lemon yellow, intensifying to bright lemon yellow on the legs. The anterior region of the carapace and the antennular and antennal bases are orange-red; the small and especially the large chelae are lemon yellow at the proximal ends, changing to almost blood red at the tips. Some other specimens show a similar color pattern except that the red of the tips of the chelae is restricted to irregular patches surrounded by white. It is not known how well this pigmentation parallels that found in the living specimens.

Crinitus Subgroup

Alpheus alcyone de Man

Alpheus alcyone de Man, Senckenb. Naturf. Gesell. Abhandl. 25: 870, pl. 27, fig. 61, 1902.

Alpheus aculeipes Coutière, Fauna and Geog. Maldive and Laccadive Archipelagoes 2 (4): 892, pl. 79, fig. 31, 1905.

Alpheus alcyone de Man, Siboga Exped. 39a¹ (2): 351.

LOCALITIES: One specimen at E-1-285; 1 at E-1-611; 1 at E-1-617; 1 at E-1-648; 5 at E-2-382.

Alpheus arnoa sp. nov.

Fig. 5

TYPE SPECIMEN: A non-ovigerous female, 12.2 mm. long, collected on Arno Atoll, Marshall Islands, by R. W. Hiatt at station E-2-343. Only specimen known.

DESCRIPTION: Frontal region of carapace extending considerably beyond eyes. Rostrum short, triangular, reaching about 0.5 the length of visible portion of first antennular article; dorsally bearing a strong and abrupt carina that extends to slightly posterior of gastric region. Orbital hoods rounded, somewhat inflated, anteromedially extending into flattened area, at highest about equal in height to dorsal carina, laterally demarcated by an abrupt groove from carapace which covers base of antennal peduncle. Orbitocarinal groove shallow and rounded; orbitorostral area flattened.

Second antennular article slightly less than twice as long as broad, 1.5 times as long as visible portion of first article, 1.7 times as long as third article; diameter only 0.6 that of the first article. Stylocerite acute, with tip reaching almost to end of first article. Basicerite unarmed. Scaphocerite with lateral margin strongly concave, spine heavy, somewhat blunt, reaching beyond end of antennular peduncle; squamous portion narrow and shorter, reaching to middle of third antennular article. Carpocerite reaching to end of scaphocerite.

Large chela subcylindrical, slightly tapering, entire, 2.8 times as long as broad, with the fingers occupying the distal 0.3. Dactylus arched and rounded, calcified and white distally. Tip of fixed finger similarly calcified. Merus 0.37 as long as chela, with outer face 1.8 times as long as broad; all margins unarmed, but inferior internal margin projecting into a low but strong extension. Chela with

only sparse scattered setae. Small chela 3.5 times as long as broad, with simple conical fingers occupying the distal 0.38. Carpus somewhat elongate. Merus slightly longer (about 10%) than that of large cheliped, 2.5 times as long as broad, also unarmed. Chela bearing a moderate growth of setae on superior distal face.

Carpus of second legs with the ratio: 10:21:8:7:11.

Ischium of third legs bearing strong tooth. Merus 4 times as long as broad, armed with a strong acute tooth distally. Carpus unarmed except for poorly developed distal inferior tooth, 0.3 as long as merus. Propodus 3.5 times as long as broad, 0.66 as long as merus, armed on inferior margin with five strong spines and five weaker spines. Propodus and dactylus with usual scattered sparse setae. Dactylus curved, simple, and well developed. Fourth legs of similar armature and proportions.

Telson 2.4 times as long as posterior margin is broad, anteriorly 1.4 times as broad as posteriorly, sides with slight taper; anterior pair of dorsal spines 0.39, posterior pair 0.60 of length posterior from articulation; distal lateral spines moderately strong; strongly arcuate distal margins armed with numerous short heavy spines. Outer uropod with strong lateral spine and with distal margin armed with numerous shorter spines in addition to usual setae. Inner uropod bearing eight strong spines on distolateral margin and numerous short heavy spines similar to those of the telson along distal margin.

DISCUSSION: This species belongs to the *Crinitus* subgroup, and within the subgroup it appears to be most closely related to those other species with an extended dorsal carina, *A. bucephaloides* Nobili, *A. longecarinatus* Hilgendorf, and *A. parvus* de Man. From the first two species it can most easily be distinguished by the lack of spines on the carpus of the third legs. *A. parvus* lacks the armature of the carpus, like this species, but the configuration of the anterior margin of the cara-

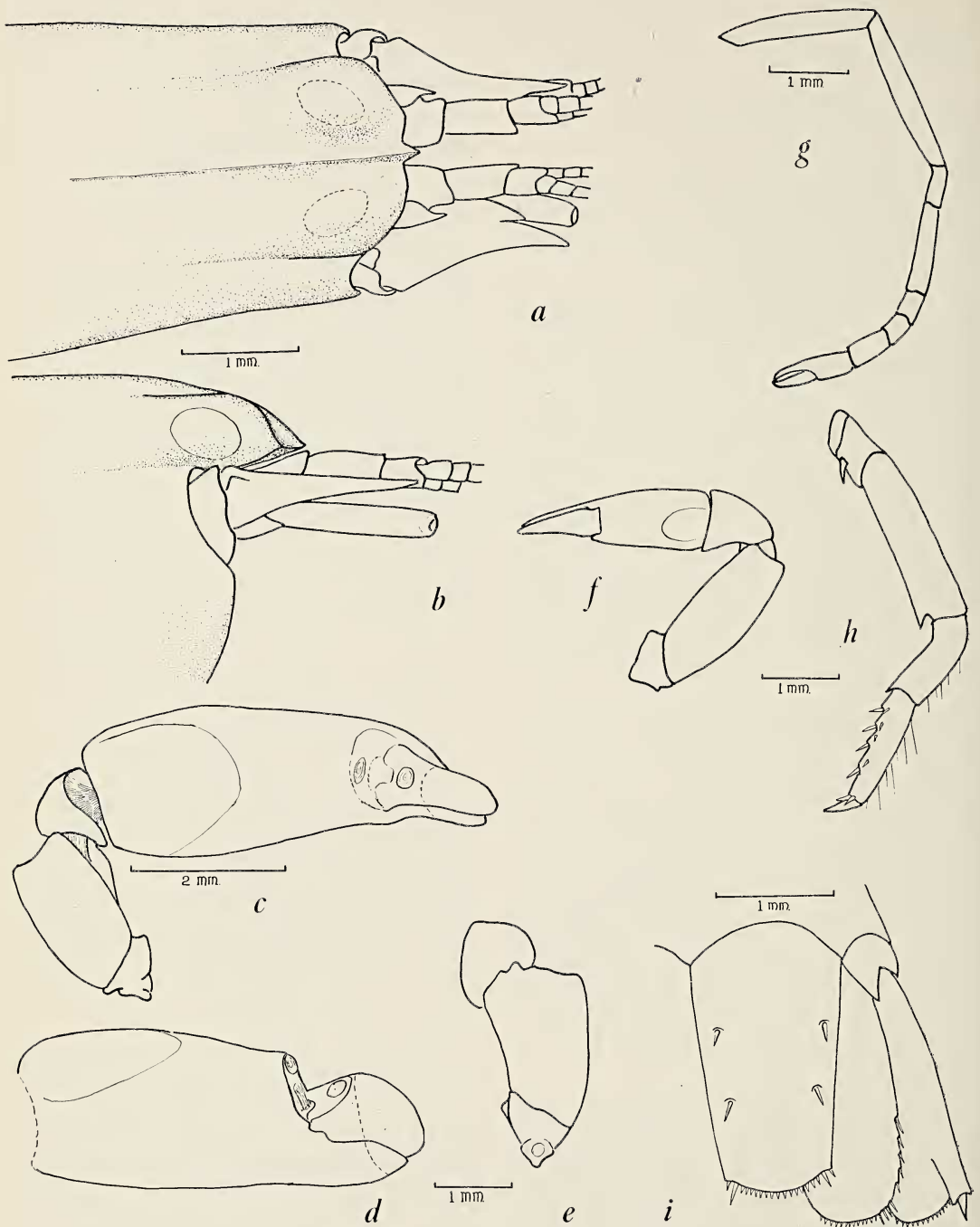


FIG. 5. *Alpheus arnoa* sp. nov. *a, b*, Anterior body region; *c*, large cheliped, lateral aspect; *d*, large chela, inferior aspect; *e*, large cheliped, merus, medial aspect; *f*, small cheliped; *g*, second leg; *h*, third leg; *i*, telson and uropods.

pace is different, (compare Fig. 5a to de Man, 1911, pl. 15, fig. 74), the flattened portion of the scaphocerite is longer and more narrow, the second carpal article is only 1.3 instead of 2.1 times as long as the first, the telson is more tapering and the spines and spinules of the uropods and telson were unreported by de Man.

The specific name refers to the type locality.

Alpheus bucephalus Coutière

Alpheus bucephalus Coutière, Fauna and Geog. Maldive and Laccadive Archipelagoes 2(4): 890, pl. 78, fig. 29, 1905.

Alpheus consobrinus de Man, Leyden Rijks Mus. van Natuurlijke Hist. Zool. Meded., Notes 30:101, 1908.

Alpheus consobrinus de Man, Siboga Exped. 39a¹: 360, pl. 16, fig. 75, 1911.

LOCALITIES: One specimen at E-1-122; 11 at E-1-306; 4 at E-2-360.

DISCUSSION: *A. consobrinus* was recognized by de Man as being closely related to *A. bucephalus* and *A. clypeatus* Coutière, but was separated by him on the basis of the following characteristics:

1. The scaphocerite is slightly longer than the carapocerite in *A. consobrinus* and slightly shorter in *A. bucephalus*.

2. The basicerite is armed with a minute tooth in *A. consobrinus* and unarmed in *A. bucephalus*.

3. The merus of the large chela bears an acute tooth on the inferior internal margin in *A. consobrinus* while in *A. bucephalus* the corresponding projection is rounded.

4. The small chela is usually dimorphic in *A. consobrinus*, the males bearing an expanded dactylus with a fringe of setae, while in *A. bucephalus* the dactylus of the small chela of the male is narrow, conical and without a fringe of setae, a condition similar to that of the females.

5. The second article of the second leg is three times the length of the first in the males

of *A. consobrinus* while in both sexes of *A. bucephalus* (according to de Man's key) it is "more than twice as long as the first." (However, Coutière's figure 29c shows it to be about 2.75 times as long as the first.)

6. The telson is slightly more narrow in *A. consobrinus*, the length-breadth ratio being 2.6, while in *A. bucephalus* where the ratio is 2.2.

This impressive list of differences would lead one to believe that the species are separate and distinct. However as previously reported from Saipan, the broadening of the dactylus of the males is not a constant characteristic. In this series of specimens a group collected at E-1-306 shows that each one of these characteristics is individually variable. In Table 1 a tabulation of these characteristics of 10 intact specimens is given. The relative lengths of the scaphocerite and carapocerite are quite variable; the spine of the basicerite is present in only two specimens; the meral spine of the large chela varies from strong and acute to low and rounded; the dimorphic character of the small chela of the males does not seem to be correlated with size or other characteristics; the ratio of the first two secondary articles of the second leg varies from 1.7, a figure below that of *A. bucephalus*, to 3.5, a figure above that of *A. consobrinus*; and, finally, the telson length-breadth ratio ranges from 2.1 to 2.9, the last in the smallest specimen. Moreover, the variations are not correlated with each other, so a specimen like *A. consobrinus* in the sexually dimorphic chela does not have the tooth on the basicerite, etc.

These variations parallel or exceed the variations previously reported upon for the closely related *A. clypeatus* Coutière and *A. brevipes* Stimpson (Banner, 1953: 103-110). I believe that when sufficient specimens are examined from all parts of the range of these four nominal species, it is very likely that the species will all be found to be part of a single, very variable species. However, the present series of specimens do not offer enough direct evidence to warrant this lumping except to combine *A. consobrinus* with *A. bucephalus*.

TABLE 1
 VARIATION IN ONE SAMPLE OF *Alpheus bucephalus* COUTIÈRE

Sex	Length, mm.	Length of scaphocerite compared to carapocerite	Tooth on basiscerite	Tooth on mesus of large cheliped	Length of second carpal article + length of first	Telson, length + breadth at base	SMALL CHELA OF MALES								Sexual Dimorphism
							A	B	A/B	C	B/C	D	C/D	Setae	
♀*	13.4	equal	abs	strong, acute	1.7	2.2	Length Palm, mm.	(lacking)	Length Palm + length, Dactylus	Breadth Dactylus at base, mm.	Length Dactylus + breadth	Breadth Dactylus 0.3 distance from base, mm.	C/D	..	.
♀*	11.2	scaphocerite longer	pres	strong, acute	2.3	broken	1.07	1.04	1.0	0.40	2.7	0.40	1.0	fringe	yes
♂*	10.3	equal	abs	low, obtuse	2.7	2.3	1.15	0.95	1.3	0.29	3.3	0.22	1.4	scattered	no
♀	6.5	equal	abs	lacking	1.8	2.8	1.00	1.00	1.0	0.37	2.9	0.37	1.0	fringe	yes
♂	9.3	scaphocerite longer	abs	low, rounded	1.9	2.1	1.18	1.33	0.9	0.51	2.6	0.55	0.9	fringe	yes
♂	8.7	carpocerite longer	abs	strong, obtuse	2.5	2.4	1.00	1.00	1.0	0.37	2.9	0.37	1.0	fringe	yes
♂	8.5	carpocerite longer	abs	strong, acute	3.5	2.6	1.18	1.33	0.9	0.51	2.6	0.55	0.9	fringe	yes
♂	8.1	scaphocerite longer	abs	strong, acute	2.8	2.5	1.00	1.00	1.0	0.37	2.9	0.37	1.0	fringe	yes
♂	8.1	carpocerite longer	pres	strong, acute	2.9	2.1	1.18	1.33	0.9	0.51	2.6	0.55	0.9	fringe	yes
♂	7.6	carpocerite longer	abs	low, rounded	2.2	2.9	1.00	0.62	1.7	0.29	2.1	0.15	1.9	scattered	no

* Ovigerous females

***Alpheus clypeatus* Coutière**

Alpheus clypeatus Coutière, Fauna and Geog. Maldive and Laccadive Archipelagoes 2 (4): 897, pls. 81–82, fig. 36, 1905.

LOCALITIES: Three specimens at E-1-306 (fragmentary and uncertain); 4 at E-1-617; 5 at E-1-648; 4 at E-2-343.

***Alpheus pachychirus* Stimpson, 1860**

For synonymy, see Banner, 1956.

LOCALITY: Two specimens at E-1-290.

***Alpheus frontalis* H. Milne-Edwards, 1837**

For synonymy, see Banner, 1956.

LOCALITY: Two specimens at E-1-611.

Diadema Subgroup

***Alpheus bidens* (Olivier)**

Palaemon bidens Olivier, Encyclopédie Méthodique, Histoire Naturelle 8: 663, 1811.

Alpheus bidens H. Milne-Edwards, Histoire Naturelle des Crustacés 2: 353, pl. 24, figs. 11, 12, 1837.

Alpheus tridentatus Zehntner, Rev. Suisse de Zool. 2: 204, pl. 8, fig. 24, 1894.

LOCALITIES: Two specimens at E-2-360; 1 at E-2-382.

DISCUSSION: These specimens show considerable variation from each other despite the fact that there are only three specimens involved. On one specimen the dorsal denticles of the anterior carapace reach almost to the base of the eyes, while the other two are considerably shorter (but not placed as far posteriorly as indicated by de Man, 1911: pl. 17, fig. 80). The rostrum on one does not reach quite to the end of the first antennular article, on the second reaches slightly beyond it, and on the third reaches almost to the middle of the second article. The first antennular article bears one movable spine and two long setae in two of the specimens, but in the

third carries one spine on one side and two spines (as shown by de Man) on the opposite article. On the merus of the large chela the armature varies, with one specimen bearing feeble spines on the inferior internal margin, only several exceedingly weak spines on superior margin, while the inferior external margin carried only about 10 poorly developed serrations; on the second specimens the spines of the inferior internal are quite strong, the superior margin carries 7 short but strong spines, and the serrations on inferior external margin are marked; the third specimen is intermediate between these two.

However in other characteristics, these specimens compare sufficiently well to the descriptions of the species that these variations cannot permit one to consider them as other than this species.

***Alpheus diadema* Dana, 1852**

For synonymy, see Banner, 1956.

LOCALITIES: Two specimens at E-1-149; 1 at E-1-290; 2 at E-2-343; 2 at E-2-360.

***Alpheus percyi* Coutière**

Alpheus percyi Coutière, Soc. Philomath. Paris, Bul. 9(5): 21, 1908.

Alpheus percyi Coutière, Linn. Soc. London, Trans., Zool. II, 17(4): 426, pl. 64, fig. 22, 1921. [Same description, figures added.]

LOCALITY: Two specimens at E-2-382.

DISCUSSION: This specimen agrees very well with the specimens from the Hawaiian archipelago except for the rostrum. In the Hawaiian species the rostrum bears a low, obtuse but definite crest, but in these two specimens the rostrum is dorsally flat and smooth. While Coutière does not discuss this characteristic in his original description, his figures in his 1921 publication (figs. 22, 22¹) seem to indicate a condition similar to these Marshall specimens. It may be that the Hawaiian specimens will be found to represent a geograph-

ically isolated subspecies, but not enough specimens are known to draw any conclusions as yet.

Alpheus gracilipes Stimpson, 1860

For synonymy, see Banner, 1956.

LOCALITIES: Two specimens at E-1-306; 2 at E-1-387; 3 at E-1-617.

DISCUSSION: Of these 7 specimens, 2 males and 2 females had their small chelae intact; all 4 had the characteristic fringe of hair over the dactylus, but none had their fingers noticeably broadened. These specimens, therefore, are like the form found in Hawaii and not like the form from the Marianas.

Alpheus paracrinitus var. *bengalensis* Coutière, 1905

For synonymy, see Banner, 1956.

LOCALITY: One specimen at E-1-106.

Edwardsi Group

Alpheus crassimanus Heller

Alpheus crassimanus Heller, Reise der . . .
Novara . . . Zool. Theil 2(8): 107, pl. 10,
fig. 2, 1865.

LOCALITIES: One specimen at E-1-387; 2 (fragmentary) at E-1-670; 3 at E-2-311.

DISCUSSION: The fragmentary specimens were assigned to this species because those parts remaining were almost identical to specimens of similar size from Hawaii.

One specimen was somewhat unlike the rest with the sculpturing on the large chela deeper and more abrupt, and the second and third legs thinner and more elongate (the merus of the third legs is 6 times as long as broad instead of the reported 4.5 to 5.0 times). However similar variation in the large chela has been reported for Hawaiian specimens (Banner, 1953: 134), and for this comparison, the meri of a group of specimens

collected from a single area in Kaneohe Bay, Oahu, Hawaii, were measured, and it was found that the length-breadth ratio varied from 4.5 to 6.0.

Alpheus strenuus Dana

Alpheus strenuus Dana, U. S. Explor. Exped.
13(1): 543, pl. 34, fig. 4, 1852.

LOCALITIES: One specimen at E-2-169; 6 specimens, Arno, records lost.

DISCUSSION: Some of these specimens, the largest I have yet seen, reach a total body length of 57 mm.; Coutière (1905: 913) has reported specimens reaching 95 mm., but his figures included the chelae.

The distinction between this species and *A. audouini* described by Coutière in 1905 appears to be somewhat questionable. Coutière makes the distinction upon the form of the anterior carapace and rostrum, and the form of the large chela, but the distinctions are so fine as to be scarcely apparent in his figures. Considering the variations that have been reported for other species of the genus, these fine distinctions appear to be of dubious validity. Probably the best differentiations may be found in the antennular base, where the median article is 1.5 times the length of the distal article in *A. audouini* and 2 times the length in *A. strenuus*; in the second legs, where the first article is 1.65 times the length of the second in *A. audouini* and 1.0 to 1.2 times the length in *A. strenuus*; and in the merus of the third legs where the length is 4.3 times the breadth in *A. audouini* and 3.7 times the breadth in *A. strenuus*. Even these differences could easily be within the normal range of variation for an inherently variable species.

Alpheus pacificus Dana, 1852

For synonymy, see Banner, 1956.

LOCALITY: Three specimens at E-1-106.

Alpheus dolerus Banner

Alpheus dolerus Banner, *Pacific Sci.* 10 (3): 362, fig. 2.

LOCALITIES: One specimen each at E-1-617 and E-2-343.

DISCUSSION: While these specimens compare well to the types and paratypes from Saipan, positive identification is impossible because both are females, and males are necessary for identification in this group.

Alpheus parvirostris Dana, 1852

For synonymy, see Banner, 1956.

LOCALITIES: Three specimens at E-1-106; 11 at E-1-122; 9 at E-1-149; 1 at E-1-285; 1 at E-1-290; 6 at E-1-306; 1 at E-1-387; 1 at E-1-611.

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